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ABSTRACT

Recent research leaves unsettled the role of education in the recent fall of productivity growth. Part of this dilemma is due to two major methodological problems in the estimation of education's contribution to productivity growth: the methods for deriving weights for returns to education, and the interaction among education and other factors influencing the quality of labor. To reduce these problems, researchers must derive alternative methods for growth-accounting research. New policies to increase productivity should be examined within a context that accords high priority to two policy concerns: equity and the level of government expenditure. Other areas to be examined include the disaggregation of returns to education, links between education and work, federal spending on education, education and taxes, and the effectiveness of schooling. The National Institute of Education can play one of several roles in resolving these methodological issues. For example, it could focus on a reexamination of the role of education in growth accounting, or it could examine a large number of the research issues relevant to the role of education in productivity growth, including the policy issues mentioned above. (This analysis is one in a series on the relationship between productivity and education.) (MN)

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THE CONTRIBUTION OF EDUCATION TO PRODUCTIVITY:

The Need for New Research and Possible NIE Roles in this Research

Ed Dean
November 12, 1980

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The rate of growth of productivity in the U.S. economy has declined dramatically in recent years. Productivity grew at a rate of 3.2 percent per year in 1948-65, according to one study.* This growth rate fell to 2.3 percent in 1965-73 and declined still further to 1.1 percent in 1973-78.

In the late 1960s and early 1970s, economists believed that education was one of the major causes of the high growth rate of productivity in the post-World War II period. More recent research leaves unsettled the role of education in the recent fall in productivity growth. Has education been a positive factor, resisting the decline in productivity growth? Has productivity in education itself stagnated, thereby contributing to the decline in productivity growth? If education has remained a positive factor, can it help reverse a decline in productivity growth that has originated through the workings of other factors?

Whatever the answers to these questions, in the current environment it seems incumbent on us to seek answers to the questions of the role that education should play in

-- any national reindustrialization policy;

-- restoring our competitive position in the world marketplace.

We should also seek answers to the corollary questions:

-- are our current educational institutions up to the above tasks?

-- are our current educational policies in need of change?

This paper reviews briefly what is known and what needs to be known about the role of education in productivity. It also suggests possible roles that NIE might play in re-defining research issues and stimulating research pertinent to the design of educational policies conducive to rapid productivity growth.

* J. R. Norsworthy, M. J. Harper, and K. Kunze, "The Slowdown in Productivity Growth: Analysis of Some Contributing Factors," Brookings Papers on Economic Activity, No. 2 (1979), p. 392. The measure used in this calculation is output per hour of labor input in the private business sector. See ... below on alternative ...

I. RESEARCH ON THE ROLE OF EDUCATION IN PRODUCTIVITY GROWTH

Education as a Source of Productivity Growth: Research through the early 1970s.

Early attempts to analyze the growth of output in the U.S. economy gave rise to a large "residual"--an increase in output not due to increases in any input. The residual was so large that researchers began to search for concrete ways of explaining it.* A number of researchers quickly pointed to improvements in the quality of the labor force, due mainly to increased education, as a major, previously unmeasured, source of growth in output. In 1970, Griliches published research results indicating that increased educational attainment accounted for one-third of the residual.** Such results seemed especially credible in light of the first results of the then recently developed human capital literature. In the early 1960s, Becker had estimated that the rate of return to investment in college education was high--higher in fact than the rate of return on alternative investments.*** It appeared that investment in college education had been insufficient to drive the rate of return down to the level of the return on other investments.

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* This research is discussed briefly in Zvi Griliches, "Notes on the Role of Education in Production Functions and Growth Accounting," in W. Lee Hansen, ed., Education, Income and Human Capital, National Bureau of Economic Research, Studies in Income and Wealth, Vol. 35 (New York: Columbia University Press, 1970), pp. 71-115.

** Griliches, "Role of Education in Growth Accounting," p. 79.

*** Gary S. Becker, Human Capital (New York: Columbia University Press, 1964), Chapters IV and V.

The research results of Edward Denison--a pioneer in the measurement of sources of economic growth or "growth accounting" as the techniques have come to be called--have been consistent with other research results showing that education contributed mightily to the growth of total output and of productivity.

In 1974, Denison published his results for the period 1929-69.* While no one table can adequately reflect the richness of Denison's work, the attached table 1 shows results especially relevant to the present discussion. This table shows that in 1964-69, the growth in national income per person employed in the nonresidential business sector (henceforth, this concept will be loosely referred to as labor productivity**) was 1.85 percent (see last column,

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* Edward F. Denison, Accounting for United States Economic Growth, 1929-1969 (Washington, D.C.: Brookings, 1974).

** The relation of labor productivity to other measures of productivity may be best understood on the basis of a simple production function, such as the following:

$$Q = f(L,K),$$

where Q is quantity of output (for example, net national product, national income, gross domestic product, or the business sector component of any of these three quantities), L is labor input and K is capital input. (Denison and others use land as a third input in some calculations, but land inputs play a small role in most computations of sources of growth and may safely be ignored in the present discussion).

Under certain rather rigid but commonly used assumptions, the relative weights of labor and capital in producing output may be assigned on the basis of their respective shares in output, measured in current prices. Thus, the weight associated with labor inputs, W_L, is the ratio of total labor compensation to output. Similarly, the weight associated with capital, W_K, is the ratio of nonlabor payments to output. Payments to all inputs equal the monetary value of output. Hence, $W_L + W_K = 1$.

(note continued on page 5)

Table 1

Nonresidential Business: Sources of Growth of Sector Actual National Income per Person Employed, 1948-69
Contributions to sector growth rate in percentage points

	1948-53	1953-64	1964-69
Sector national income per person employed	2.85	2.93	1.85
Total factor input	0.90	0.55	0.08
Labor	0.47	0.15	-0.18
Hours	-0.08	-0.25	-0.29
Age-sex composition	0.09	-0.11	-0.38
Education	0.46	0.51	0.49
Capital	0.48	0.41	0.36
Inventories	0.15	0.09	0.11
Nonresidential structures and equipment	0.33	0.32	0.25
Land	-0.05	-0.01	-0.10
Output per unit of input	1.95	2.38	1.77
Improved resource allocation	0.49	0.28	0.42
Economies of scale	0.58	0.40	0.68
Irregular factors	-0.74	0.31	-0.74
Advances in knowledge and n.e.c.[a] (residual)	1.62	1.39	1.41

a. n.e.c.: not elsewhere classfied

Source: Denison, Accounting for Growth, p. 120.

Note continued

We are now in a position to define the two most commonly used measures of productivity growth, total factor productivity and labor productivity, and to show the relation between them.

The growth in total factor productivity (where P_T is total factor productivity) may be defined as the growth in output that is not due to the growth in inputs. If we confine ourselves, again, to labor and capital inputs, we have

$$(1) \qquad \Delta P_T = \Delta Q - (W_L \Delta L + W_K \Delta K)$$

where Δ indicates percentage change. This equation may be read as follows: the percentage change in total factor productivity, ΔP_T, is equal to the percentage change in output minus the sum of the percentages changes in labor and capital, where each is weighted by its respective share in output.

To use an illustration, let $\Delta Q = .04$, $\Delta L = .02$, $\Delta K = .03$, $W_L = .7$ and $W_K = .3$. Then, based on eqt. 1, the growth in total factor productivity is $.04 - .023 = .017$ or 1.7 percent.

The growth in labor productivity (where P_L is labor productivity) is the growth in total output not due to the growth in labor input, or $\Delta P_L = \Delta Q - \Delta L$. By placing ΔQ on the left side of eqt. 1, and subtracting ΔL from both sides, we obtain

$$\Delta Q - \Delta L = \Delta P_T + W_L \cdot \Delta L + W_K \cdot \Delta K - \Delta L.$$

Collecting terms on the right side, we obtain

$$(2) \qquad \Delta Q - \Delta L = \Delta P_T + W_K (\Delta K - \Delta L).$$

Using our previous numerical illustration, we obtain the result, on the left side, that the growth in labor productivity, ΔP_L, is equal to $\Delta Q - \Delta L$ $(= .04 - .02) = .02$. On the right side, we obtain $\Delta P_T + W_K (\Delta K - \Delta L)$ $(= .017 + .3 (.03 - .02)) = .02$.

Hence, the growth in labor productivity (.02), is equal to the growth in total factor productivity (.017), plus the change in capital per unit of labor (.03 - .02) weighted by the share of capital in output (.3).

Both labor productivity and total factor productivity are legitimate measures of productivity.

Two final observations: The above discussion ignores the fact that there are several possible alternative definitions of labor productivity. Denison uses output per person employed; others have used output per hour worked. Also, the above discussion does not attempt to incorporate quality adjustments in the measurement of inputs. See table 1 for a reflection of Denison's procedures on quality adjustment; see also Norsworthy, Harper and Kunze, "Slowdown in Productivity Growth," pp. 394-95.

top row). Of this increase in labor productivity, only 0.08 percentage points were due to increases in inputs of all factors, after adjustments for composition and quality, while 1.77 percentage points were due to increases in output per unit of input.

Denison's research indicated that education accounted for .49 percentage points, out of the total of 1.85 percentage points, of the increase in labor productivity over the period 1964-69. That is, education accounted for over one-quarter of the total increase in labor productivity. However, this contribution of education reflects only the effect of education in improving the quality of the labor input. It does not reflect any influence of education on improvements in technology or management practices. Denison also concluded that "advances in knowledge and not elsewhere classified" accounted for 1.41 percentage points of productivity growth (see table 1). These 1.41 percentage points are in actuality Denison's residual: his label reflects his view that advances in knowledge accounted for most of the residual.* Denison's "advances in knowledge" is most definitely not simply an alternate name for improvements in production processes due to education, though it does reflect (among other things) R and D and the ways in which new knowledge affects technology and management.

In sum, Denison's 1974 study indicated that education had a clear .49 percentage point influence on growth through its influence on the quality of labor, while knowledge production in a more general sense was (among other things) reflected in another 1.41 percentage point influence on productivity growth.

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* Denison, Accounting for Growth, pp. 62, 76-83, and 131.

Education as a Source of Productivity Growth: Recent Research

Research results in the late 1970s on the role of education in productivity growth provided few settled answers and raised many questions.

In a 1979 book,* Denison specifically addressed the issue of accounting for slower economic growth. Analyzing the period 1973-76, Denison found that labor productivity fell five-tenths of a percentage point per year. (See table 2.) This was not particularly surprising, since by 1976, the U. S. economy had only partially recovered from the severe 1974-75 recession. The results of Denison's allocation of productivity growth to education and other sources was more surprising: improvements in the quality of labor due to education accounted for nine-tenths of a percentage point in the growth of labor productivity, more than the growth rate itself.

This large positive source of productivity growth was of course offset by other negative sources, including a negative nine-tenths of a percent due to a decline in output per unit of input. The largest source of this decline was the residual itself: taken at face value, "advances in knowledge and not elsewhere classified" accounted for a negative seven-tenths of a percentage point. Denison wrote, "what happened is, to be blunt, a mystery."**

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* Edward F. Denison, Accounting for Slower Economic Growth: The United States in the 1970s (Washington, D.C.: Brookings, 1979).

** Denison, Slower Economic Growth, p. 4. Denison examined 17 possible reasons for the large negative residual, but concluded that the problem required intensive additional research (Slower Economic Growth, p. 147).

Table 2

Sources of Growth of National Income Per Person Employed, Nonresidential Business Sector, 1948-73 and 1973-76

Percentage points

Item	1948-73	1973-76
Growth rate	2.4	-0.5
Irregular factors	-0.2	0.1
Adjusted growth rate	2.6	-0.6
Total factor input	N.A.[a]	0.3
Changes in labor characteristics		
Hours at work	-0.2	-0.5
Age-sex composition	-0.2	-0.3
Education	0.5	0.9
Changes in capital and land per person employed		
Nonresidential structures and equipment	0.3	0.2
Inventories	0.1	0.0
Land	0.0	0.0
Output per unit of input	N.A.[a]	-0.9
Improved allocation of resources	0.4	0.0
Legal and human environment	0.0	-0.4
Economies of scale from larger markets	0.4	0.2
Advances in knowledge and n.e.c.[b] (residual)	1.4	-0.7

a. N.A.: Not Available
b. n.e.c.: not elsewhere classified

Source: Denison, Slower Economic Growth, Table 1-1, p. 2 and Table 7-3, p. 94.

It has also been asserted that "Joseph Pechman, Herbert Stein, and Albert Rees have all turned the slump in productivity growth 'a mystery'."*

In addition to Denison, other researchers have found that education has made a positive and/or growing contribution to productivity growth, even during the recent slowdown in productivity growth.**

In light of these puzzling results, we should examine two major methodological problems in the estimation of education's contribution to productivity growth.

1. Methods for deriving weights for returns to education. Practitioners of growth accounting generally use earnings of factors of production to estimate the marginal products of the factors. In his estimation of the relative contribution to output of workers with different amounts of education, Denison weights education groups by relative earnings of workers in each group.*** His

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* Shlomo Maital and Noah M. Meltz, "Summary and Conclusions," in Maital and Meltz, eds., Lagging Productivity Growth: Causes and Remedies (Cambridge, Mass.: Ballinger, 1980), p.274. On the other hand, Norsworthy, Harper, and Kunze have little difficulty in accounting for the slowdown in 1973-78: capital effects of various types account for the greater part of the slowdown. See their "Slowdown in Productivity Growth," pp. 415-421. Michael Darby, of U.C.L.A. speaking before a recent meeting of the National Economists Club, stated that unlike almost everyone else, he did not find slow productivity growth a mystery: productivity growth in 1965-78, in his view, was only slightly below its over-all trend figure for the 20th Century.

** John W. Kendrick, "Productivity Trends in the United States," in Maital and Meltz, eds., Lagging Productivity Growth, p. 26; Norsworthy, Harper and Kunze, "Slowdown in Productivity Growth," pp. 408-09 and 413-17. (Norsworthy, Harper, and Kunze do not show a direct measure of education's contribution, but their figures indicate that it is large.)

*** Denison standardizes for age, region, color and attachment to farm or nonfarm occupations before calculating earnings differentials received by workers of different education levels. He also attempts to eliminate that part of the correlation between education and earnings due to academic aptitude and socioeconomic status of parents. See his Slower Economic Growth, p. 44 and Appendix F and Accounting for Growth, Appendix I.

estimate of the contribution of education to productivity growth during 1973-76 is made on the basis of relative earnings of different education groups as of a much earlier date, 1969. Denison's procedure would lead to an over-estimation of the contribution of education to growth if the 1973-76 differences in earnings between highly educated and less well educated workers were smaller than in 1969.*

Other researchers also derive weights for returns to education from relative earnings statistics for a specific year or set of years, prior to the period they are analyzing.

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* Denison is aware of Richard Freeman's conclusion that the earnings advantages of college graduates relative to high school graduates had diminished by the early 1970s. He examines the pertinent data and rejects Freeman's results. Denison lays special emphasis on a very large figure, reported by the Current Population Survey, for 1968 earnings of male college graduates in the 55-64 age group. Denison argues that this figure is too large to be plausible and would distort a comparison of relative earnings of college and high school graduates between the late 1960s and later. Finis Welch also provides insightful analysis of Freeman's research. See Denison, Slower Economic Growth, pp. 164-66; Richard Freeman, "Overinvestment in College Training?" Journal of Human Resources, Vol. 10 (Summer 1975), pp. 287-311; Richard Freeman, The Over-Educated American (New York: Academic Press, 1976); and Finis Welch, "Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust," Journal of Political Economy, Vol. 87, No. 5, Pt. 2 (October 1979), pp. S65-S97. EPOs Educational Finance Program has recently completed an RFP on the rate of return to college education which calls for further analysis of this controversy. The RFP, may it RIP, is in C & G.

The proponents of the "screening hypothesis" have argued that the observed correlation between earnings and educational attainment is due not to the productivity of education but to the use of educational credentials in screening job applicants. It might be argued that Denison, by standardizing his earnings differentials by age, region, color, and attachment to farm or nonfarm occupations, and by his attempts to adjust these figures also for the influence of academic aptitude and parental socioeconomic status, eliminates part but not all of the effects of screening. The RFP mentioned above also calls for a reassessment of the relative merits of the screening hypothesis and human capital theory as approaches to interpreting the earnings-education correlation.

2. Interaction among education and other factors influencing the quality of labor. The choice of statistical procedure to be used in adjusting labor inputs for quality of education can make a great deal of difference in the measured contribution of education to productivity growth. Denison's procedures for deriving the earnings weights to be used for different educational groups have just been noted. In addition, Denison allocates portions of the growth of productivity to other variables related to labor inputs: among these, it is noteworthy that the quantity of labor input is adjusted for the age-sex composition of the labor force and that part of the improvement in output per unit of input is ascribed to improved allocation of labor resources between farm and nonfarm work. Both of these adjustments are performed independently of the calculation of the impact of education on labor quality.

Other researchers have recently argued that the adjustment of the labor input for quality change must take account, in a uniform fashion, of all dimensions of labor quality. In particular, improvements in the quality of labor due to increased education can occur simultaneously with changes in variables that reflect other dimensions of labor quality. Hence the net impact of education on labor quality could be more or less than the impact of education considered alone, due to interaction between the movements in education and the other variables affecting labor quality. A study by Peter Chinloy calculates that the "main effect" of education on labor quality in 1971 to 1974 was to cause an increase in labor quality of .67 percent per year. However, if the

impact of education is computed after labor quality adjustments have already been made for sex, class, age, and occupation, this effect is reduced to .41 percent.*

The present point is not that Denison's estimate of the impact of education on economic growth is too high or too low;** nor is it that Denison's methods are superior or inferior to Chinloy's. Instead, the point is that the various methods may give considerably different results for the impact of education on growth and that the current state of the art does not permit a determination as to which methods are best.

Conclusions

Five broad conclusions emerge from the examination of research to this point:

1. All of the growth accounting studies examined indicate that education continued to make a positive contribution to the growth of productivity during the recent period of drastic slowdown in productivity.

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* Peter Chinloy, "Sources of Quality Change in Labor Input," American Economic Review, Vol. 70, No. 1 (March 1980), esp. pp. 115-17. See also Norsworthy, Harper, and Kunze, "Slowdown in Productivity Growth," and F.M. Gollop and D. W. Jorgenson, "U.S. Productivity Growth by Industry, 1947-73," in John W. Kendrick and Beatrice N. Vacarra, eds., New Developments in Productivity Measurement and Analysis (Chicago: University of Chicago Press for National Bureau of Economic Research, 1980), pp. 17-124.

** On the one hand, Chinloy's methods do not permit of a judgment whether his lower or higher figure is the more accurate. On the other hand, it is not clear whether Denison's methods would give a lower or higher result than Chinloy's if performed on the same data over the same period of time.

2. This is hardly surprising, given the fact that the research methods used in these studies are similar in several critical respects. For example, all weight the different levels of educational attainment by earnings; in a period of continued increase in educational attainment and persistently higher earnings by more highly educated people, an improvement in the measured quality of labor will necessarily result.* As another example of similarity in research methods of different researchers, none of these studies attempts to examine the functioning of educational establishments to determine whether they are more or less productive than they used to be.

3. The various studies yield different results as to the degree of importance of education in contributing to productivity growth during a period of productivity slowdown.

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* This comment is not intended to suggest that the weighting procedures used are somehow suspect, or clearly wrong. On the contrary, the weighting procedures rest on widely accepted assumptions and defensible aspects of microeconomic theory. However, given the trends just mentioned, a large role for education in productivity is more or less built into the data, and careful scrutiny of the methods used is called for. For example, if the screening hypothesis, discussed briefly above, is correct, then the high rate of return received by the highly educated is not due solely to their higher productivity, but at least partly to the persistence of credentialism in hiring practices.

4. A number of prominent economists interested in growth accounting research are at a loss to explain the recent drastic slowdown in productivity growth.* A number have used the term "mystery."

5. The study of the role of education in economic productivity is complicated by important unresolved methodological problems.

What is to be done?

In the remainder of this paper, four tasks are undertaken.

1. A brief statement is made as to the value and importance of making progress toward resolving certain methodological problems in growth accounting.

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* It may be noted that a large number of causal factors have been examined. Perhaps the two most widely discussed possible causes are a decline in the rate of new capital investment and a decline in spending on R and D. Other factors that have been widely discussed are (1) higher real marginal tax rates that discourage effort and investment in human capital; (2) new requirements for business spending on environmental protection and health and safety; (3) lower worker motivation; (4) ineffective management; (5) changing composition of the work force, including a growing proportion of relatively inexperienced women and young workers; and (6) rapidly rising energy prices.

It should also be noted that some researchers have followed an approach quite distinct from the growth accounting approach to examining the factors causing changes in productivity. This approach is to explain the variation in rates of change of total factor productivity across industries through the use of multiple regression methods. This effort appears to have borne rather little fruit. A major difficulty faced by practitioners of this approach has been the high degree of correlation between the dependent variable, productivity change, and several of the explanatory variables. See John W. Kendrick and Elliot S. Grossman, Productivity in the United States: Trends and Cycles (Baltimore: Johns Hopkins University Press, 1980), Chapter 6.

2. Tentative ideas are put forth as to new research efforts, within the framework of growth accounting, that might shed light on the role of education in productivity.

3. Further ideas are set forth as to additional research--outside the growth accounting framework--that might assist policymakers in designing national educational policies more conducive to productivity growth.

4. Finally, the paper presents several alternative NIE strategies for fostering research on the role of education in productivity.

II. BUILDING A BETTER MOUSETRAP

Two methodological problems concerning the measurement of education's contribution to productivity were examined above. Economists working on growth accounting are wrestling with additional problems. Some of these problems relate directly to the measurement of education's contribution, others do not. However, a new research procedure need not relate directly to the measurement of education's contribution to affect the measurement of education's contribution: if a procedure increases or decreases the measured contribution of another input, the proportionate role of education may be affected.

These methodological problems need not be examined in detail.* Since growth accounting provides the framework for most informed analysis of

* They may, however, be outlined briefly.

1. Most research in growth accounting relies on several rather rigid assumptions, including the assumption that the monetary returns to all factor inputs equal their contributions to output and that firms are in equilibrium with respect to their major and subsidiary products. Are these assumptions essential? Could they be relaxed if new estimating procedures were devised?

the growth of productivity, it is vital that it be performed as accurately as possible. Since educational policy and the level of educational expenditure may be subjected to the test of education's contribution to productivity growth, NIE has an interest in accurate growth accounting.

(note continued)

2. Most or all growth accounting research takes the rates of return to specific factors as fixed data. In fact, however, the rates of return to factors, including the rates of return to education of different types, are determined simultaneously with the rate of growth of productivity. If productivity declines, the rates of return to factors will decline, in most cases. This, in turn, will affect the production of such factors and, eventually, the rate of growth of productivity. It should not be overwhelmingly difficult to apply methods of simultaneous estimation to growth accounting.

3. There are several alternative procedures for measuring the effects of capital input on the growth of productivity. It is not clear, however, which is best. For more detailed discussion, see Norsworthy, Harper, and Kunze, "Slowdown in Productivity Growth," pp. 398-405.

4. Most authors have not been able to incorporate into the growth accounting framework a number of developments that probably help account for the slowdown in productivity growth. These developments are trends in the ratio of hours worked to hours paid; the effect of increasing energy prices; the effect of changes in the amount of spending on R & D; the effect of increased spending on compliance with governmental health and safety and pollution abatement requirements. Some authors, however, have been able to incorporate one or more of these developments into their particular frameworks.

5. It has been suggested that official statistics exaggerate the decline in productivity due to failure to include the output of illegal or unreported activities in officially-measured output. Edgar Feige maintains that the underground economy has grown more rapidly than the "above-ground" economy, thereby causing an underestimation of economic growth. His work is discussed in the Washington Post, September 21, 1980, p. G12; I have not yet been able to obtain a copy of his study.

Other issues may be mentioned still more briefly; (1) whether output of government, nonprofit institutions, households and dwellings can be more accurately measured; (2) the appropriate measure of output of the economy as a whole; (3) whether productivity growth should be analyzed within periods defined by adjacent peaks of the business cycle or whether other periods are also appropriate; (4) whether it is appropriate to treat "economies of scale" as a source of growth.

III. PRIORITIES FOR RESEARCH: WITHIN THE GROWTH ACCOUNTING FRAMEWORK

Research on the potential future impact of education on productivity should have higher priority than research on the actual impact in the past. Whatever the actual impact has been, it would be error to ignore the possibility that this impact could be increased.

An examination of the possible future impact of education on productivity clearly raises the possibility of altering educational policies. New policies designed to increase productivity should be examined, however, within a context that accords high priority to two other policy concerns: equity and the level of government expenditure.

-- Equity. Given NIE's mandate to improve equity in education, it would be paradoxical and wrong if a new emphasis on productivity led to policies that diminished equity. An appropriate criterion for support of new educational policies and for the guidance of any new NIE-sponsored policy research would be that new policies for improving productivity should demonstrably improve equity or have a neutral equity impact.

-- Government spending. New policy proposals that would markedly increase the level of government spending on education would immediately encounter serious political opposition. In what follows, emphasis is placed on research concerning the reallocation of funds presently spent on education. A criterion for support of a new program involving increased spending on education might be that the new spending should be supported only if a cost-benefit

or rate-of-return study demonstrated that the new spending would increase the flow of economic resources in the future.

An emphasis on policies involving reallocation and innovation within the context of existing expenditure levels should be welcome if, as may well be the case, the improvement of the productivity impact of the educational enterprise depends more on how we spend funds than on how much we spend; if the effectiveness with which educational programs work, including the way educational programs relate learning to work, should be at the top of our agenda; and if much can be accomplished by altering the incentives policymakers provide to students and educational institutions.

Advances in knowledge

In his 1974 study, Denison advanced the view (as was noted above) that his large residual was due mainly to advances in knowledge. While advances in knowledge are certainly intimately connected with education and R & D activities, Denison believes that current research methods do not permit an accurate estimate to be made of the impact of R & D and education on advances in knowledge that contribute to productivity. Denison also does not believe that a recent decline in R & D spending is a major cause of the productivity slowdown.* John Kendrick, on the other hand, believes that a decline in R & D spending has contributed mightily to the productivity slowdown.** To say the least, a number of methodological problems in this

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* Denison, Slower Economic Growth, pp. 122-26.

** Kendrick, "Productivity Trends," pp. 25-26. Kendrick also believes that new Federal tax policies and subsidies designed to increase R & D, combined with other Federal tax changes to increase capital formation, could increase the contribution of technological progress to productivity by 0.5 percentage points. Kendrick, "Remedies for the Productivity Slowdown in the United States," in Maital and Meltz, eds., Lagging Productivity Growth, pp. 247-48.

area remain unresolved.*

It should be noted that a recent report to the President by the Secretary of Education and the Director of the NSF asserted that

> the one factor most likely to increase the ratio of economic growth to employment would be an increase in productivity. Such an increase will surely come, if at all, from better trained people devising new ways to use scientific and technical knowledge, and from a society that is better prepared to assimilate technology.**

Research is needed to examine the possibility that more accurate measures may be devised of the impact of education and R & D on advances in knowledge. Policy-oriented research is also needed on the comparative productivity of R & D personnel by type of personnel (basic, applied and developmental R & D personnel), and by sponsorship (corporate, university, and government.

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* See, for example, Denison, Slower Economic Growth, pp. 122-26 and Norsworthy, Harper, and Kunze, "Slowdown in Productivity Growth," p. 413.

** Secretary of Education and Director, National Science Foundation, "Report to the President of the United States," p. xxiv, in National Science Foundation and Department of Education, Science and Engineering Education for the 1980s and Beyond (October 1980).

Disaggregation of returns to education

Growth accounting studies have calculated the increase in output due to the increased number of years of schooling in the population as a whole, without disaggregation by type of schooling. Similarly, research in the human capital tradition has usually examined the rate of return to investment in education generally, without regard to type of education.* Relatively few studies have disaggregated the contribution to output or the rate of return to education by type of education.

The disaggregation of education's contribution to output may be more important, for policy formulation purposes, than the overall contribution of education treated as a single variable. The rate of return to education, broken down by industry, occupation, type of curriculum (at the high school level, vocational, general, and college preparatory), race, sex, major and institutional setting (university and college, proprietary school, and company-sponsored training) could vary widely, with clear implications for productivity as well as equity.

There are at least two reasons for the relative paucity of studies of disaggregated rates of return to education and the nearly total absence**--to my knowledge--of growth accounting studies that examine the contributions of

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* The only major exception is that a number of studies have examined the impact of a higher level of education (such as college graduation) relative to a lower level of education (such as three years of college or high school graduation).

** However, see August C. Bolino, Occupational Education as a Source of Economic Growth, U.S. Department of Labor, Manpower Administration, Grant No. 91-11-72-25, November 1972; available from National Technical Information Service, Springfield, VA. 22151.

different types of education to productivity growth. First, there are serious problems of methodology, entangled with data problems, involved in studies of this type.* Second, human capital theorists have largely accepted the proposition that, if entry to various occupations is open to all, the discounted lifetime earnings of workers in different occupations will tend toward equality, with differences reflecting mainly differences in ability, other personal characteristics, and the nonpecuniary returns from different types of work.**

It follows, then, that further attention should be given to consideration of

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* In most data sources, when the total number of observations is divided into several types of education, and the data are also cross-classified by various control variables, the number of observations for at least one type of education will tend to become quite small. Also, when particular occupations are considered, people trained in an occupation, but not actually registered or working in that occupation, tend to get censored out of the data. The same point holds, though with greater force, as regards field of study. Further, the more narrowly defined is a group under consideration, the more likely is the computed rate of return to be affected by short-term macroeconomic events. For example, some occupations, such as engineers of specialized types, have been severely affected by recent recessions. Nonetheless, as examples of studies of this type--each with certain weaknesses--see Freeman, The Over-Educated American, Chapters 4 and 5; Richard S. Eckaus, Estimating the Returns to Education: A Disaggregated Approach (Berkeley, California: Carnegie Commission on Higher Education, 1973), esp. Chapter 2. The Educational Finance Program's RFP on returns to investment in postsecondary education asks for an analysis of the existing literature and research problems associated with attempts to disaggregate rates of return by type of education and occupation and also by race, sex, and class.

** Sherwin Rosen, "Human Capital: A Survey of Empirical Research," in Ronald G. Ehrenberg, ed., Research in Labor Economics, Vol. 1 (Greenwich, Conn.: JAI Press, 1970), p. 12; Mark Blaug, "The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey," Journal of Economic Literature, Vol. 14, No. 3 (September 1976), pp. 838-39.

the proposition that lifetime earnings in different occupations tend toward equality. In this connection, researchers may need to devote additional attention to identifying entry barriers to specific occupations and to comparing rates of return in these occupations to rates in others. It is a reasonable guess that most of us will feel that it would be illuminating and relevant to policymaking to disaggregate the educational component of growth accounting studies, perhaps especially by type of education and occupation. It is not immediately clear, however, how this should be done. In a few words, the disaggregation of education's contribution to productivity is difficult, relevant to policy formulation, and deserving of greater attention.

IV. PRIORITIES FOR RESEARCH: OUTSIDE THE GROWTH ACCOUNTING FRAMEWORK

Links between education and work

The cultural context in which specific employment and educational institutions operate can determine their effectiveness.* While this cultural context cannot--almost by definition of culture--be transplanted from a host to a guest society, a society eager for rapid adaptation to new conditions can sometimes borrow and nationalize specific foreign institutions. The Japanese provide us with the proof of this proposition and also some examples of institutions we might wish to borrow.

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* Ezra F. Vogel, Japan As Number One: Lessons for America (New York: Harper and Row, 1979); Irma Adelman and Cynthia Taft Morris, Society, Politics, and Economic Development: A Quantitative Approach (Baltimore: Johns Hopkins University Press, 1967).

In a number of specific ways, it appears, the Japanese have organized training and information gathering processes so that the people who are trained or who gathered information remain for many years in positions where they can make most use of this training or information.* There appear to be at least two ways in which our society might alter institutional relationships between educational and employment institutions so as to increase the real economic returns to education and training. Further research on both possibilities would be required before they could be certified as productive.

-- The school-to-work transition. Our high rates of youth unemployment are considered by some researchers to be due largely to inadequate meshing of schools and labor market institutions.** Some researchers emphasize the importance of "prearrangement of jobs" for young entrants into the labor market and have claimed that in some countries 85 percent of new entrants have jobs several months before leaving school.*** A reduction of the sheer waste resulting from high school levels of youth unemployment would increase the returns to investment in education.

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* Vogel, Japan As Number One, pp. 37 and 46. One of the sources of Gary Becker's interest in the rate of return to human capital was the interesting fact that investments in human capital could not be secured by collateral. Hence, he wondered whether there would be under-investment in humans.

** James S. Coleman, "The School to Work Transition," in Congress of the United States, Congressional Budget Office, Report of Congressional Budget Office Conference on the Teenage Unemployment Problem: What Are the Options? (October 14, 1976).

*** Beatrice G. Reubens, "Foreign and American Experience with the Youth Transition," in National Commission for Manpower Policy, From School to Work: Improving the Transition (Washington, D.C., 1976), pp. 273-295.

-- Productivity of education in the Third Sector. A detailed discussion of Nevzer Stacey's work and how it relates to the topic at hand would appear unnecessary in a paper for EPO readers. Perhaps I should simply note that research in this area is hampered by the absence of any reliable statistics on the magnitude of the Third Sector and that the main test of our emerging opinion that Third Sector education is likely to be especially productive is whether the individual's rate of return on the sum of corporate plus employee expenditures on education is higher than other comparable rates of return.*

Federal spending on education

Current programs of Federal spending on education do not appear to reflect a concern with productivity: Federal assistance to students is based on criteria other than productivity: student choice of major and student aptitude and motivation do not enter into some of the more important grant

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* This rate of return is dependent only partly on whether an employee educated at company expense will long remain in an education-related job at the sponsoring company. While the critical research problem in this area is the paucity of relevant data, other more general research issues might be mentioned: the relative costs of postsecondary education offered by employers and schools; whether post-education productivity would be increased more by education obtained by employees through their employers or in more traditional settings; whether individuals would enter the labor market earlier if employer-provided education were more widely available; whether employer-based education could ease the problem of school-to-work transition, and accompanying high unemployment rates, frequently experienced by youth; employers' incentives to provide postsecondary education; the relative private and social costs and returns - including the humanistic values thought to be imparted in the university setting - to employer-based and other types of post-secondary education; and whether government subsidies - such as an expanded or accelerated tax write-off program - should be offered to employers providing education.

and loan programs. These programs, especially grants, reduce, but do not eliminate student incentives to choose the most remunerative occupations, hence--by a market test, at least--the most productive occupations. The Family Contribution Schedule, used widely by universities to determine the level of student aid, tends to reward families who spend current earnings rather than save. It may also be questioned whether student aid programs or Federal spending on university-based R & D tends to increase the survival chances of the better institutions.*

As indicated earlier, it would be wrong to emphasize the productivity criterion to the detriment of equity. Similarly, in the case of the finance of elementary and secondary education attention must be paid to the merits of local control and funding of schools. However, it is probably correct to state that productivity criteria with respect to educational finance policies are not receiving much attention from researchers and are not presently having their day in the court of public opinion or in the deliberations of policymakers. Based on prospective additional research--noted above--on the relative productivity of education of different types, it might be feasible to develop policies designed to direct educational resources into the most productive channels.**

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* Most of these issues are raised in the Postsecondary Educational Finance Program's Research Area Plan.

** However, there are some indications that the record of the Federal Government in educational finance indicates that it might serve, on balance, to destabilize private decisionmaking. See Richard Freeman, The Over-educated American, pp. 62-63.

Education and taxes

A complex tax system will necessarily have complex effects on students' decisions about the length and type of their educations as well as adult's decisions about the length and intensity of their working lives. Though I have not had an opportunity to examine the literature on this topic, certain general issues appear to stand out.

1. High marginal income tax rates tend to discourage investment in education, and especially investment in expensive education leading to the more remunerative types of work. This will especially be the case where the learning span is long and the earning span relatively short, since earnings would then be concentrated in a relatively small number of years.

2. Incentives to work, regardless of level of education, are diminished by high marginal rates of taxation. However, for people who have high earnings, resulting from high levels of education, the disincentive to work is especially great. This could affect numbers of hours of work per week and per year as well as retirement decisions.

3. The "income effects" of high levels of taxation probably tend to offset both of the above effects of high marginal tax rates. The higher are tax rates, the lower are net earnings. Since leisure is widely believed to be a "normal" good, lower net earnings probably lead to decisions to consume less leisure, hence to increase work.*

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* There is an extensive economic literature on this topic.

4. Since education is heavily subsidized by governments (financed through our system of taxation), people undoubtedly obtain more education than if they paid its full cost. As a crude first reaction to these complex considerations, one might suggest that the net effect of these offsetting factors is for people to obtain large amounts of education--due to subsidization--but to make their critical decisions about their education with diminished regard--due to high marginal tax rates--to the relative returns to education of different types.

5. As a final reminder of the complexity of these problems we should note that all of the above considerations could be altered or rendered irrelevant by:

-- the many loopholes, favorable to high earners, built into our tax system;

-- the impact of recent major changes in the social security system, private pension plans and retirement laws, which might have greatly altered private decisionmaking on the length of working life and hence on the period of productive pay-off for investment in education.

Effectiveness of schooling

The fact that recent growth accounting studies show a continued large contribution of education to productivity growth does not imply that the productivity of schooling itself has increased or even remained constant. First, we have noted several respects in which the methodology of the

treatment of education in growth accounting needs careful review. Second, a decline in the productivity of schools is consistent with a positive and accurately--measured contribution of education to productivity growth: the rapid increase in levels of educational attainment might have been so great as to offset a decline in the quality of graduates. Finally, as was earlier indicated, careful examination of trends in the effectiveness of schooling would be a useful means of testing the accuracy of certain conclusions, reached through growth accounting, concerning education's contribution.*

Hence, further study of trends in the effectiveness of schooling would be helpful, aside from the intrinsic interest and policy-relevance of the subject, in the further examination of the contribution of education to productivity growth in our society. A fresh examination of methods of approaching such research, without undue emphasis on trends in SAT results or results of other nationally administered tests, would appear appropriate.

V. POSSIBLE NIE ROLES

The question, "what is to be done?," was raised prior to the discussion on unresolved methodological issues and broad policy questions. This question may appropriately be altered to call attention to the alternatives that NIE itself might consider: "what is NIE to do?"

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* In a telephone conversation, John Pincus of Rand indicated that he knew of no good studies that shed light on this issue on a national basis. Studies of this issue on a local basis, he stated, have been hampered by major shifts in the student composition of the schools.

One possible response, clearly, would be "nothing." Such a response could be based on the argument that the public is not now prepared to view education from the productivity perspective. Or it could be based on the view that many components of the congeries of issues surrounding productivity fit more naturally with the mission and experience of research organizations other than NIE.

If this answer is not accepted, a possible NIE role could be examined under four headings: scope, audience, mix of collaborators, and final product. To focus our discussion of this questions, two quite distinct alternatives may be put forth.

Alternative A

One possible scope of our efforts would be to focus on the methodological issues raised by a re-examination of the role of education in growth accounting. (Hence, the issues raised under heading IV above, research outside the growth accounting framework, would not be examined.) The purpose of such an inquiry would be to assist researchers to think of this problem in a new light, and to posit new, presumably improved, methods of undertaking research.

The audience of such a piece of work would be the interested research community, though we would expect that interested researchers and their ultimate new products would reach policymakers one way or another.

Two sets of collaborators might be appropriate for such a study. Initially, a group of prominent, established scholars might meet to focus priorities and determine which issues are potentially most fruitful. Once this

task was completed, this group would then provide NIE staff with guidance in selecting a second set of people to write a number (four to seven) of commissioned papers on the defined issues. Alternatively, the members of the first group might write the papers themselves.

The final product might be a book. It would be focused mainly on methodological issues.

Alternative B

An alternative scope would be to examine a large number of the research issues relevant to the role of education in productivity growth, including the policy issues discussed above. Under this alternative, the focus of the endeavor would be on policy formation, with the examination of research methods limited to those methodological issues critical to policy formulation.

The audience of such an endeavor would be the Domestic Council (or its successor body), the Secretary of Education, state officials and perhaps OMB. We would initially approach the Domestic Council with the argument that a broad-gauged study of the role of education in productivity is needed on the following grounds: in a society where productivity growth has lagged, where improved productivity growth is needed to compete successfully with potential adversaries and highly productive allies, and where a highly educated and motivated workforce has long been considered one of our most productive resources, the most careful scrutiny of policies affecting the impact of educational policy on productivity is in order.

The collaborators in such an endeavor would include educators, economists, business people with an interest in technology and/or education, and perhaps government officials.

The product of such an endeavor might be a report to the President or a series of issue papers addressed to the Domestic Council, or the body that fulfills the present Domestic Council's functions in the new administration.*

We might also wish to consider whether we could combine Alternatives A and B, by choosing, say, two items from A and two from B.

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* A second, later study of the role of education in productivity might be suggested. This study would follow through on the policy recommendations of the first study by examining two matters: (1) The probable effect on productivity of several of the recommended policy changes could be tested, perhaps through simulation techniques, and (2) experts in our own and other cultures could examine the changes in our institutional framework and in traditional assumptions that would be needed if the full potential benefit of each recommended policy change is to be captured.